Beam monitors and etc.

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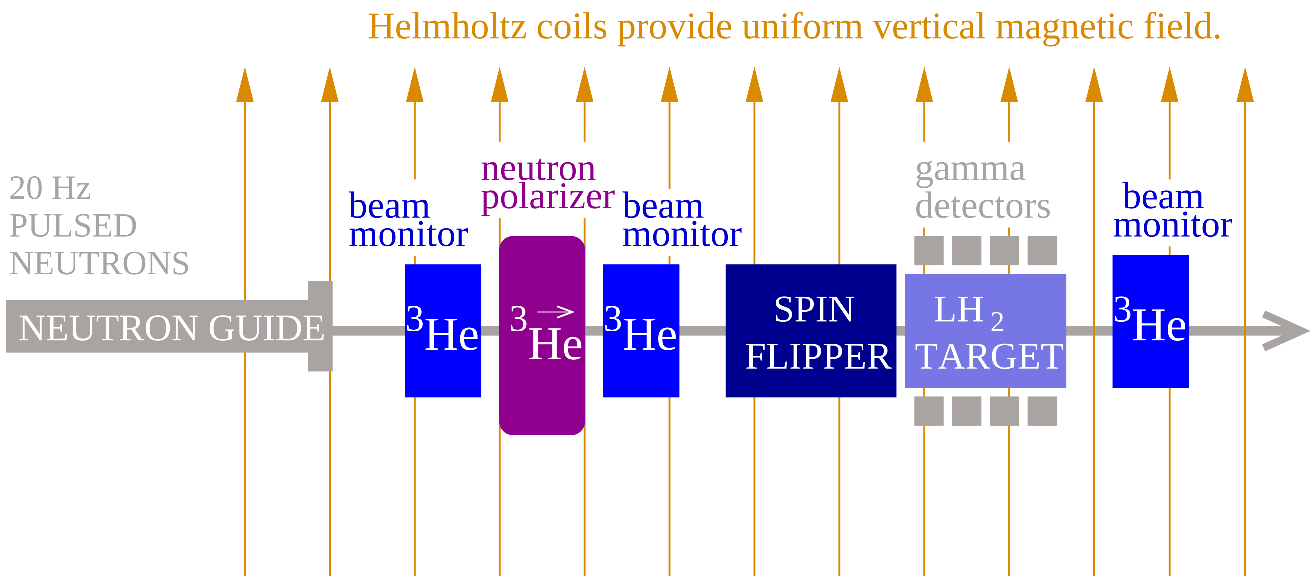
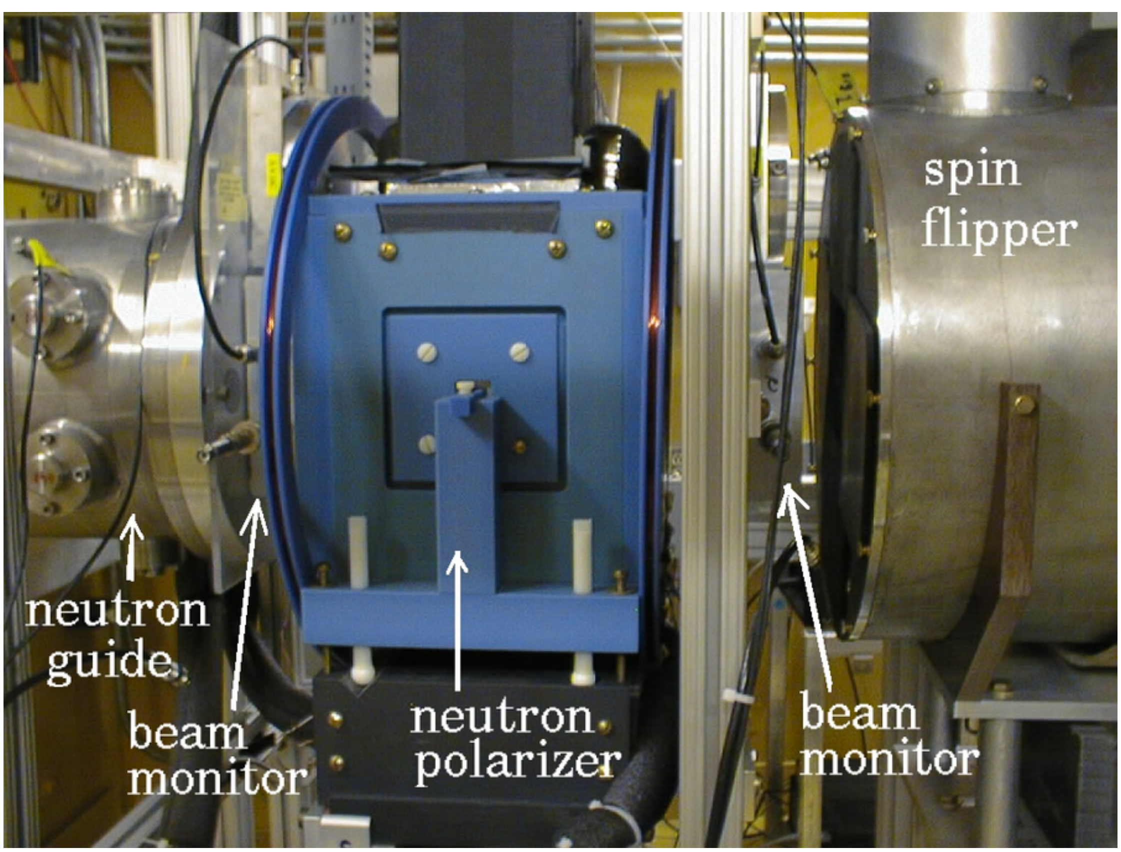
The NPDGamma Apparatus

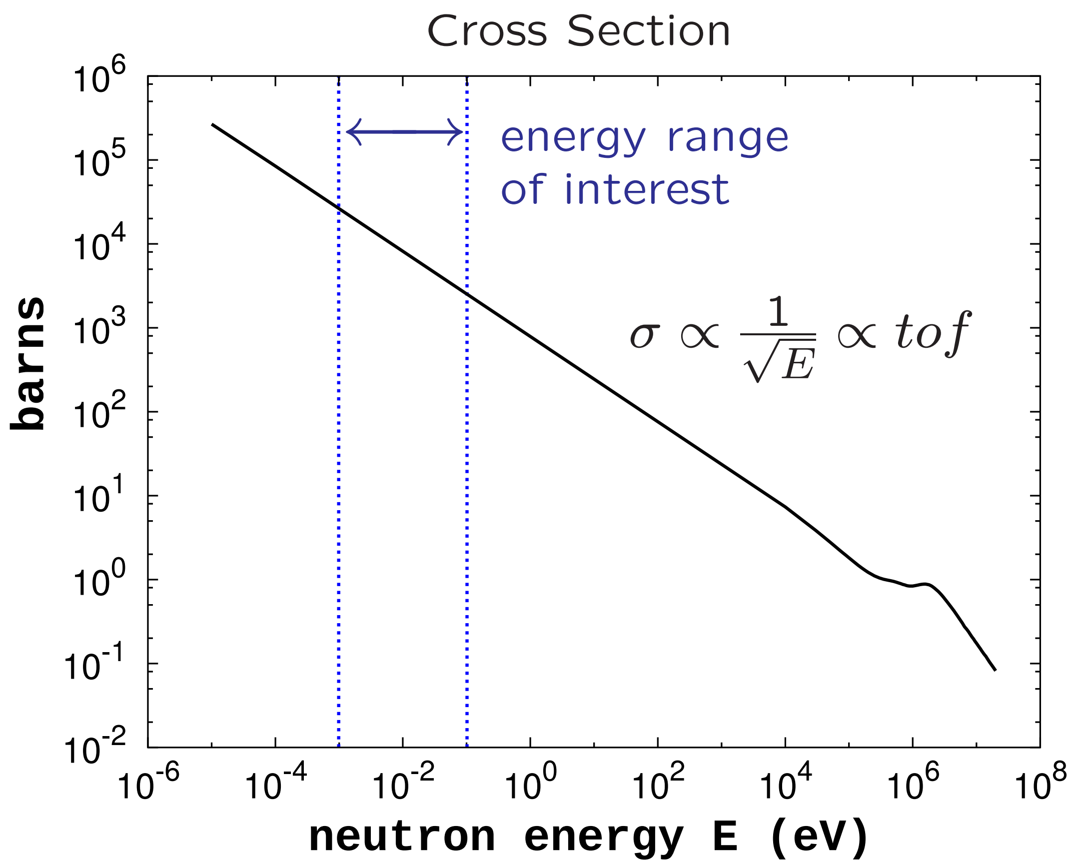


- LH_2 moderator slows neutrons (peak at 9 meV = 3 Å)
- Frame overlap chopper prevents pulse overlap
- Pulsed source provides correspondence between neutron energy and time of flight.



^{3}He **has a strong affinity for neutrons.**

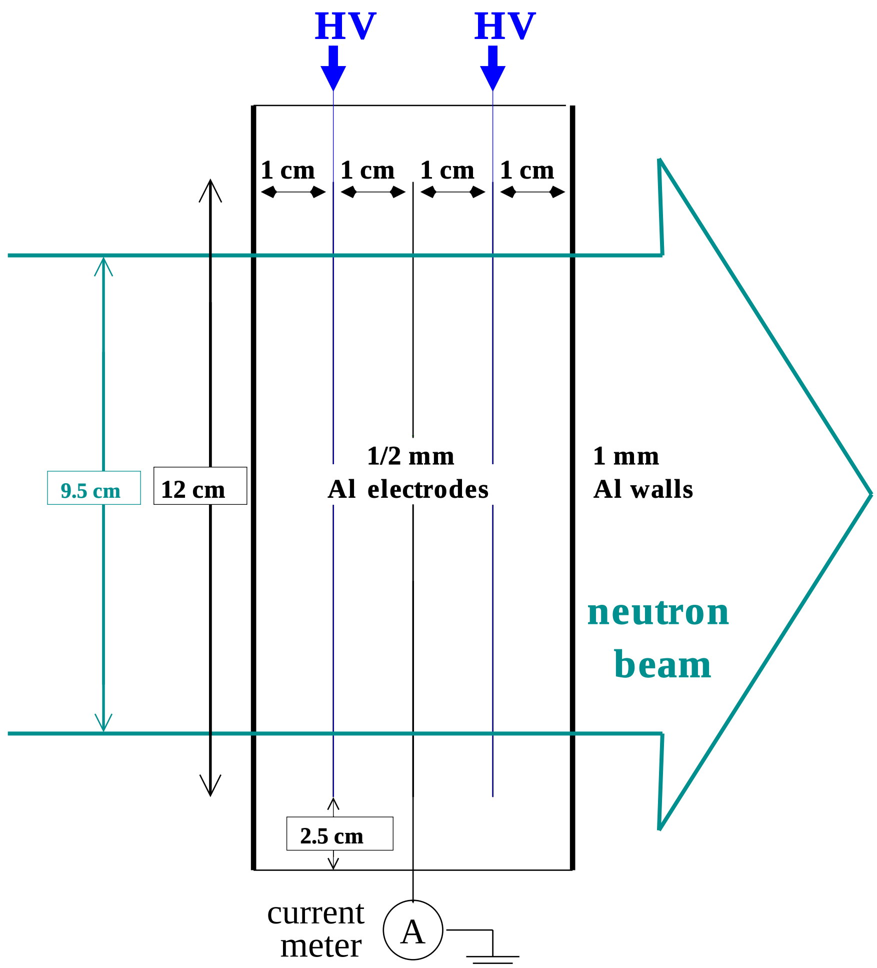
$$n + {}^3He \rightarrow p + {}^3H + 764 \text{ keV of KE}$$

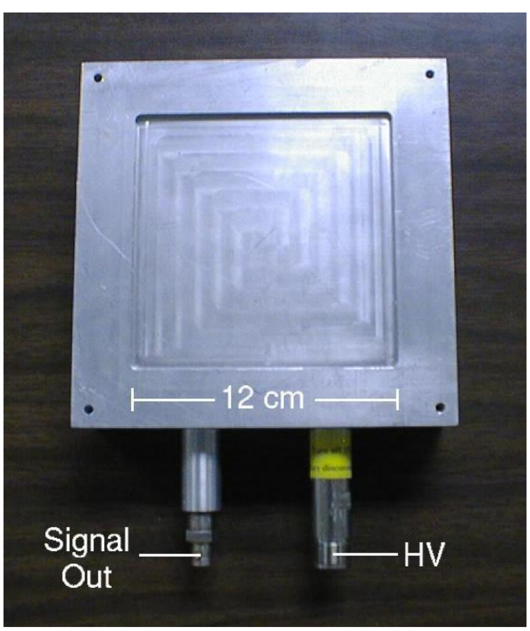


- ^{3}He pressures are adjusted according to the desired neutron absorption
- Reaction products do not interfere with the rest of the apparatus.
- Background γ-rays have a negligible effect.

The NPDGamma Beam Monitors

Primary function: To provide a signal proportional to the rate of neutrons passing through.





Gas mixture:

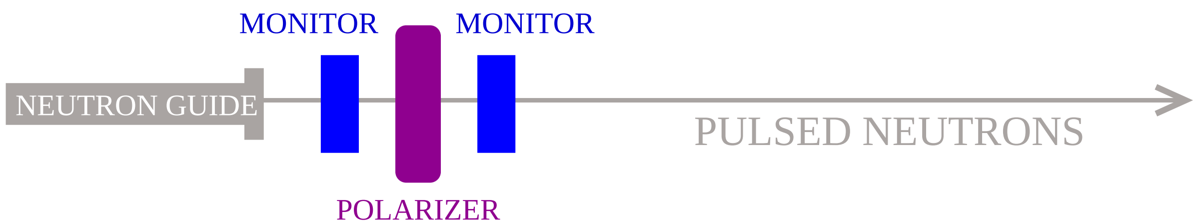
- $\frac{1}{2}$ Atm (^{3}He + ^{4}He)
- $\frac{1}{2}$ Atm N_2

Amount of ^{3}He depends on monitor's purpose

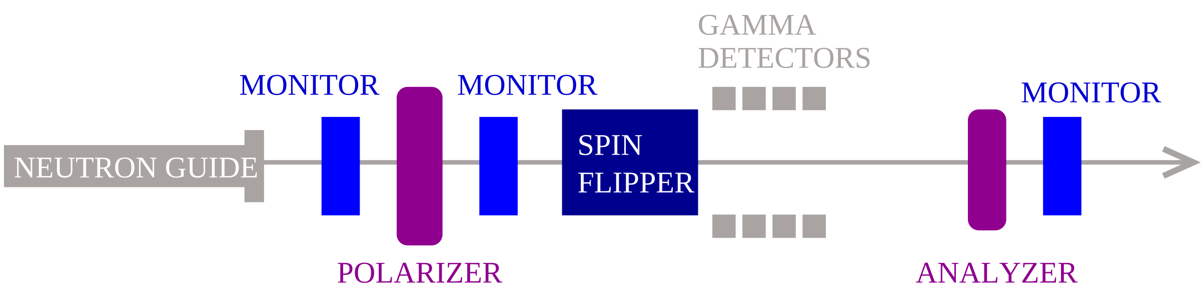
Uses of the NPDGamma Beam Monitors

Until present:

- Monitor **neutron flux.**
- Measurement of **beam polarization:**

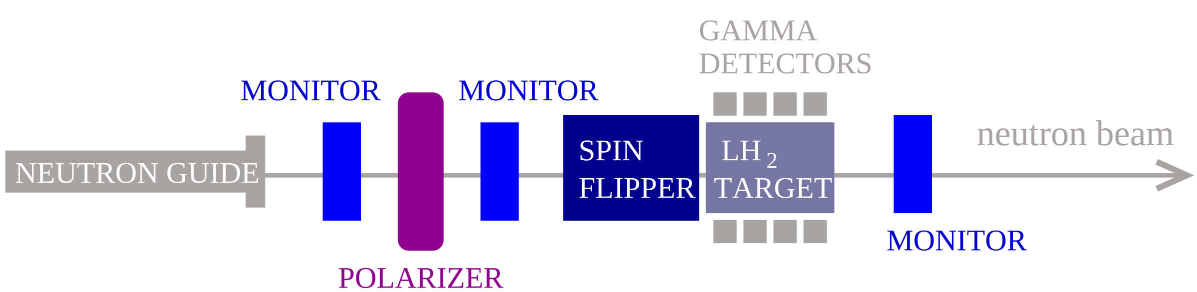


- Commissioning of the **RF spin flipper:**

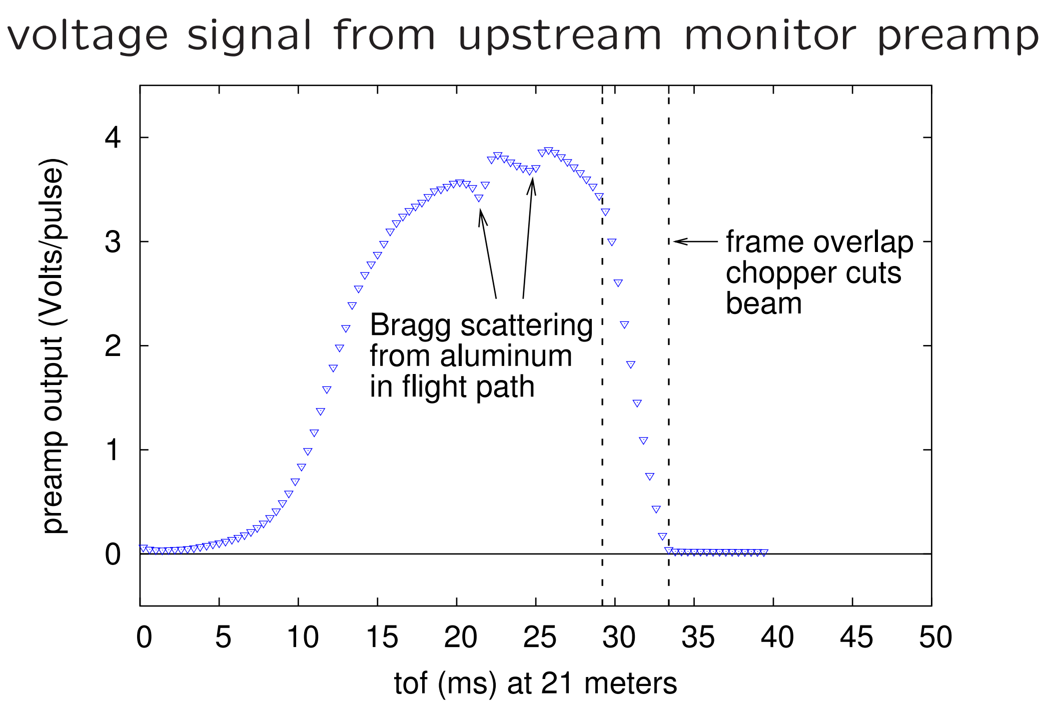


In the future:

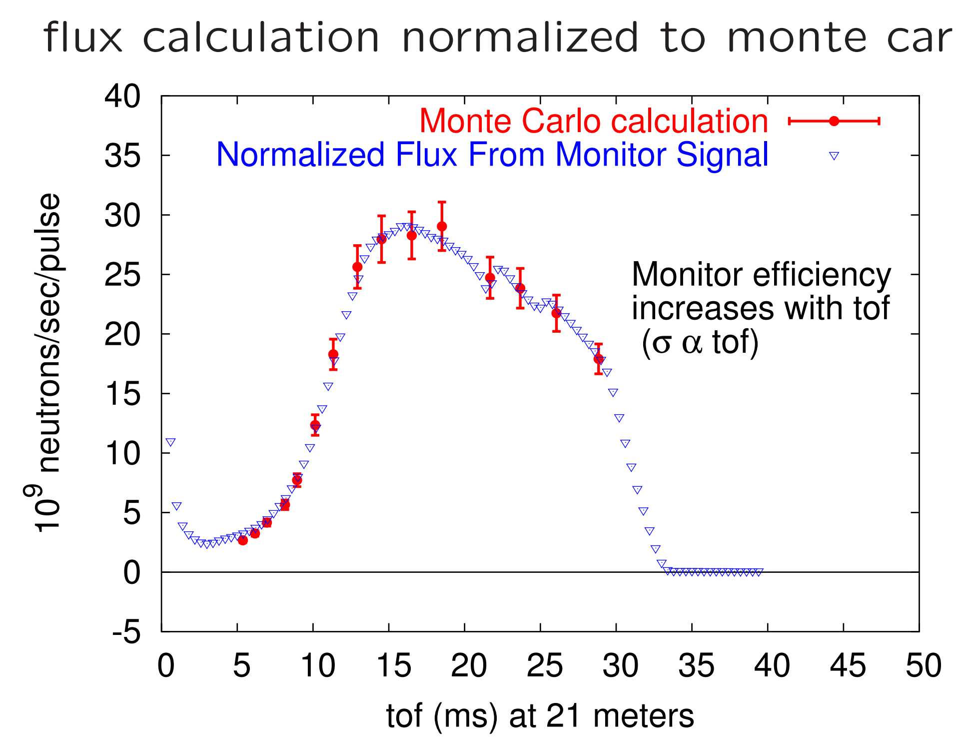
- Measurement of the **ortho-para ratio** of the **LH_2 target:**



Monitor M3



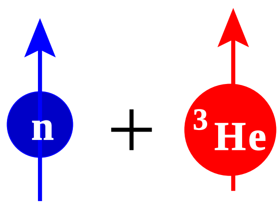
voltage signal from upstream monitor preamp
preamp output (Volts/pulse)
tof (ms) at 21 meters
Bragg scattering
from aluminum
in flight path
frame overlap
chopper cuts
beam
0
1
2
3
4
0
5
10
15
20
25
30
35
40
45
50



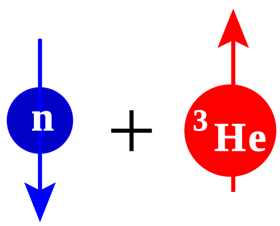
flux calculation normalized to monte carlo
10^9 neutrons/sec/pulse
tof (ms) at 21 meters
Monte Carlo calculation
Normalized Flux From Monitor Signal
Monitor efficiency
increases with tof
(σ α tof)
-5
0
5
10
15
20
25
30
35
40
0
5
10
15
20
25
30
35
40
45
50

Beam Polarizer Diagnostics

The probability of interaction for a neutron with ^{3}He is highly spin-dependent:



σ_p **~ 3 barns**

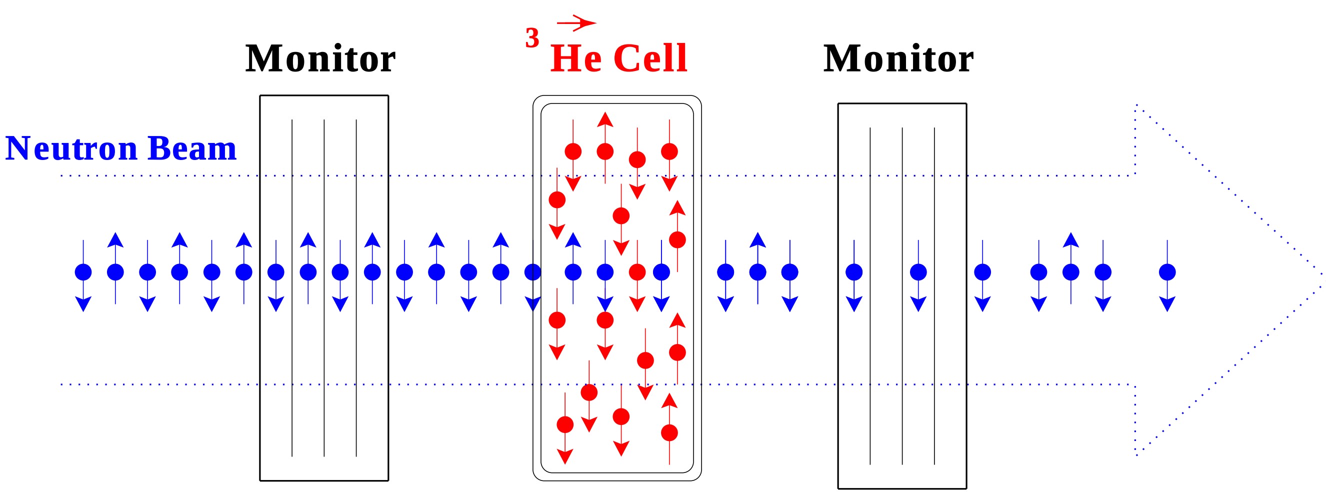


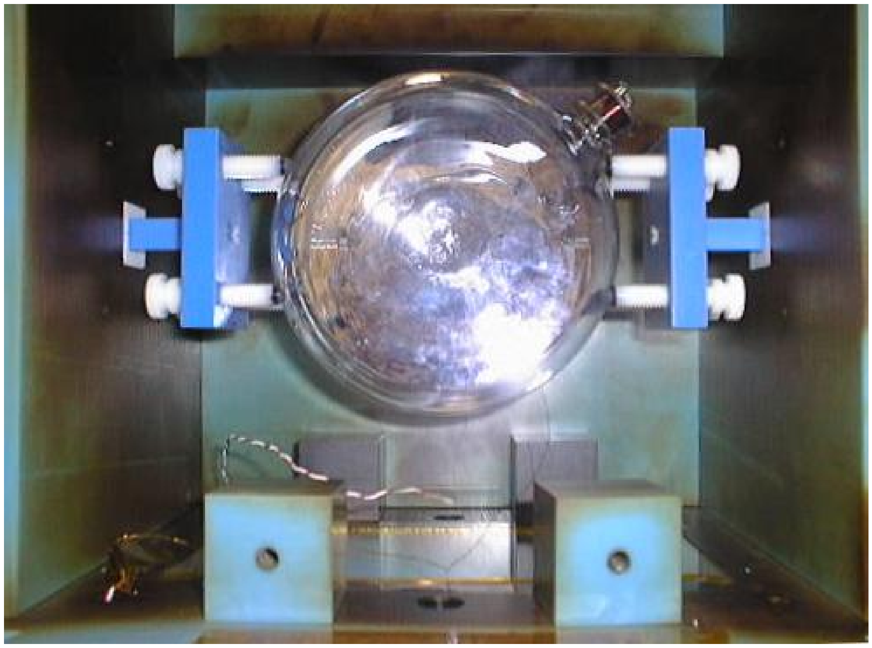
σ_a **~ 17,000 barns @ 10 meV**

$\sigma_a \;\; \alpha \;\; 1/v$ (v = neutron speed)

A cell of polarized ^{3}He filters out neutrons of one spin state.

Beam monitors are used to measure that effect.





Relative transmission through the cell polarized and unpolarized is an **absolute measure** of **neutron polarization** P_n**:**

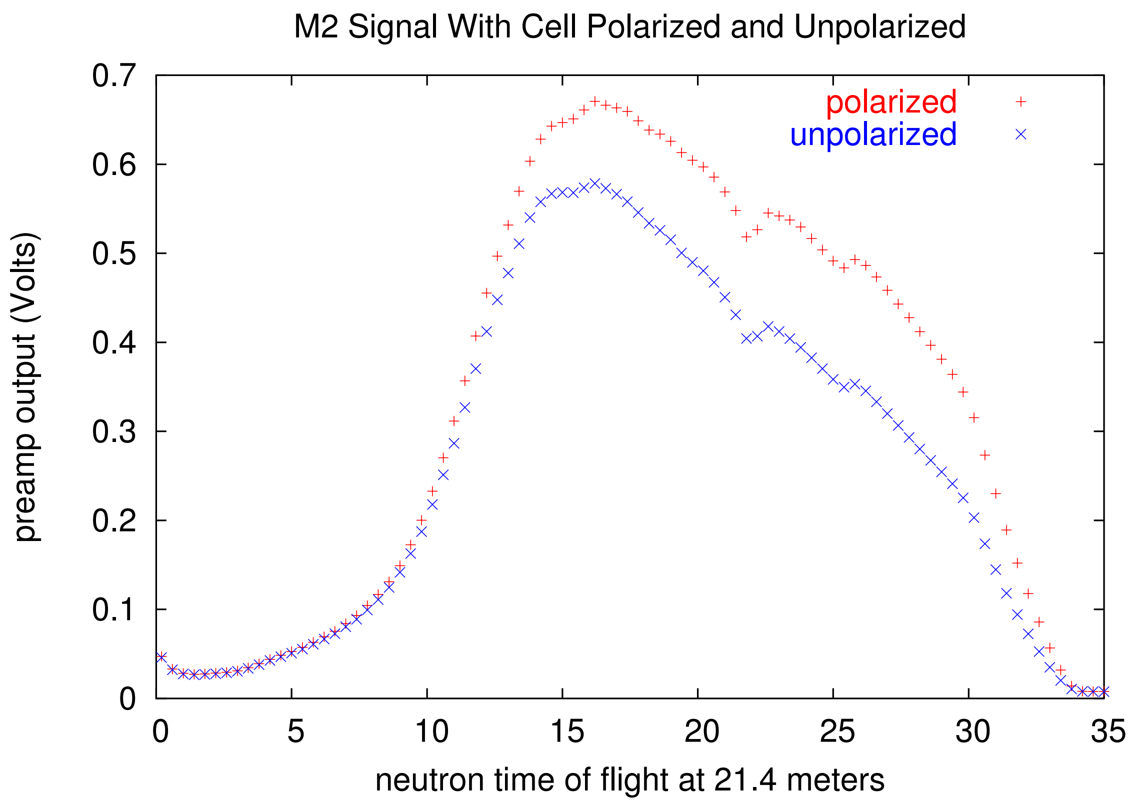
$$\boxed{P_n = \sqrt{1 - \left(\frac{T_0}{T}\right)^2}}$$

T_0 = transmission of unpolarized cell
T = transmission of polarized cell

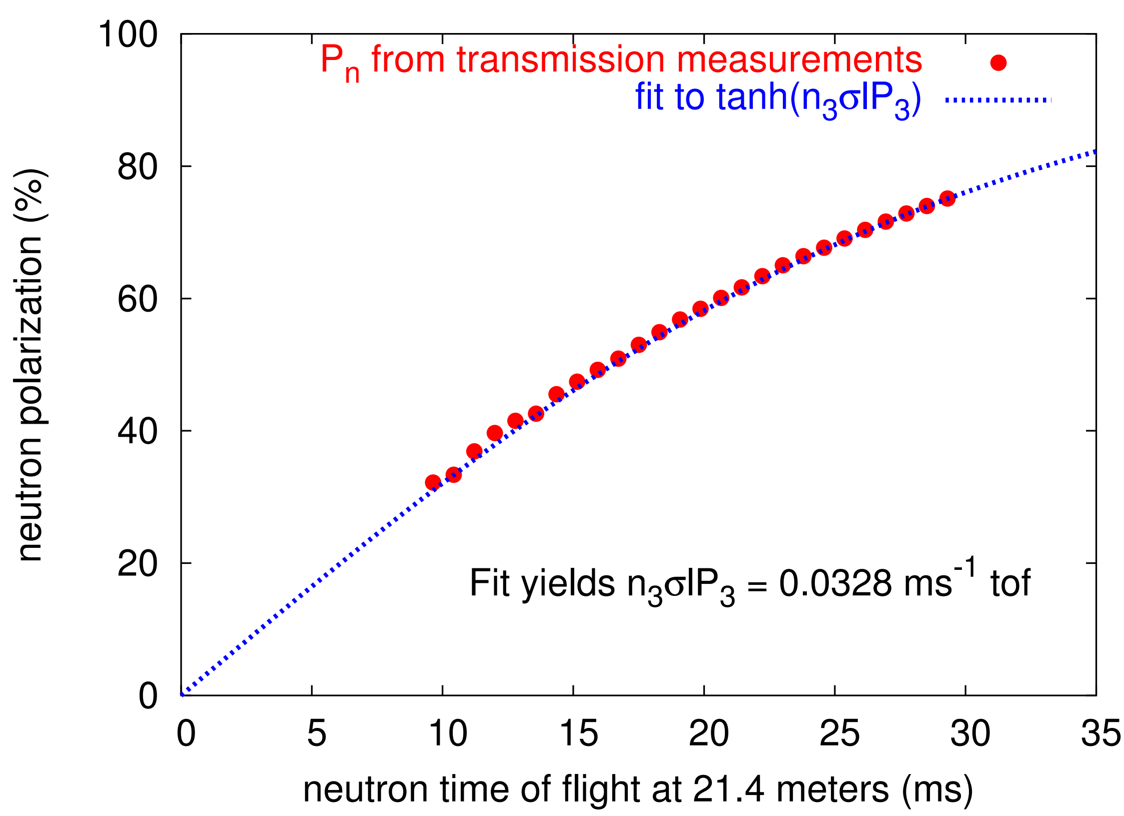
Knowing P_n and the amount of ^3He in the cell, it's possible to calculate the ^3He polarization:

$$\boxed{P_n = tanh(n_3 \sigma l P_3)}$$

P_3 = ^3He polarization
n_3 = ^3He number density
l = width of cell



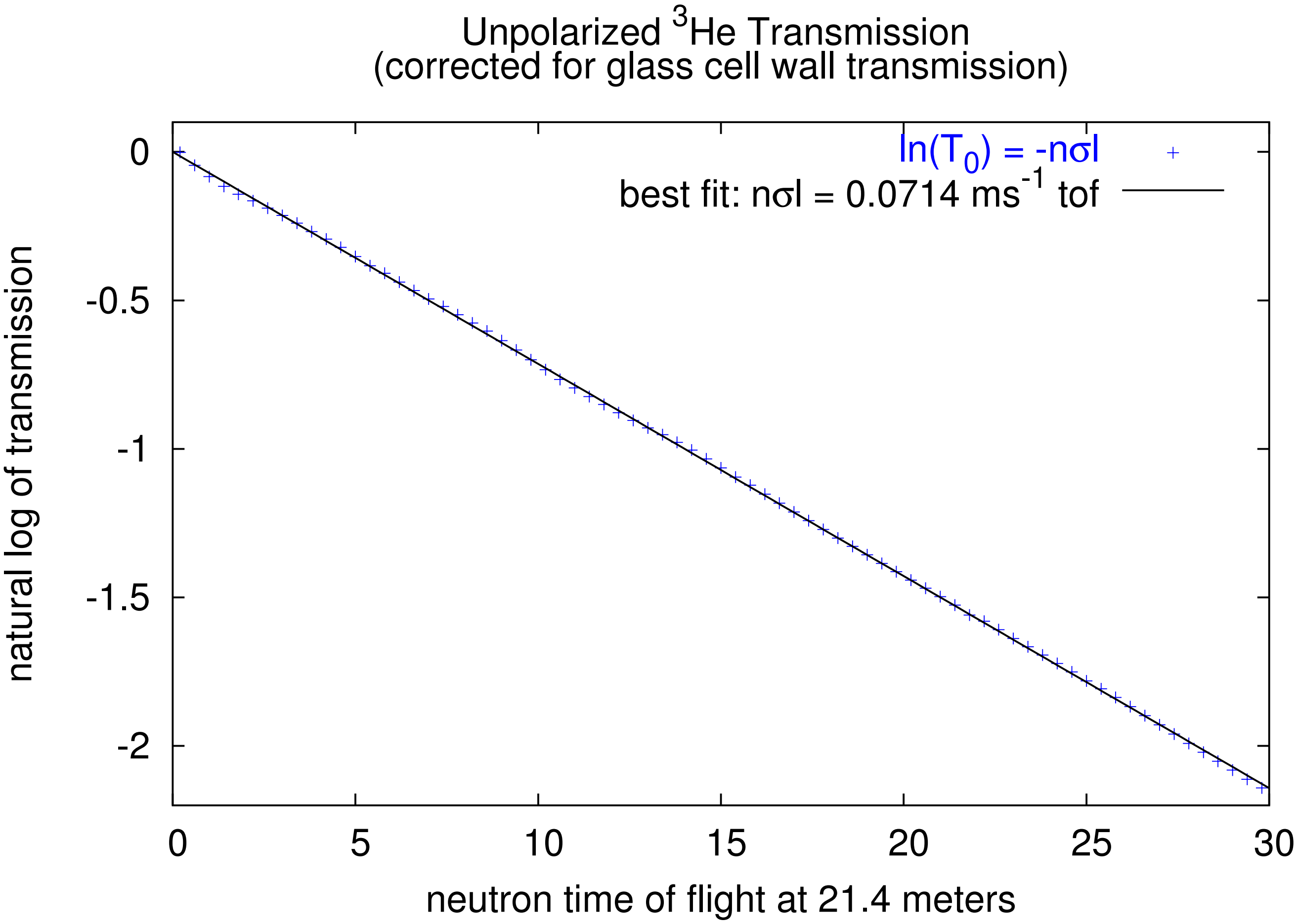
M2 Signal With Cell Polarized and Unpolarized
polarized
unpolarized
preamp output (Volts)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
35
neutron time of flight at 21.4 meters



P_n from transmission measurements
fit to $\tanh(n_3\sigma l P_3)$
neutron polarization (%)
100
80
60
40
20
0
Fit yields $n_3\sigma l P_3$ = 0.0328 ms^{-1} tof
0
5
10
15
20
25
30
35
neutron time of flight at 21.4 meters (ms)

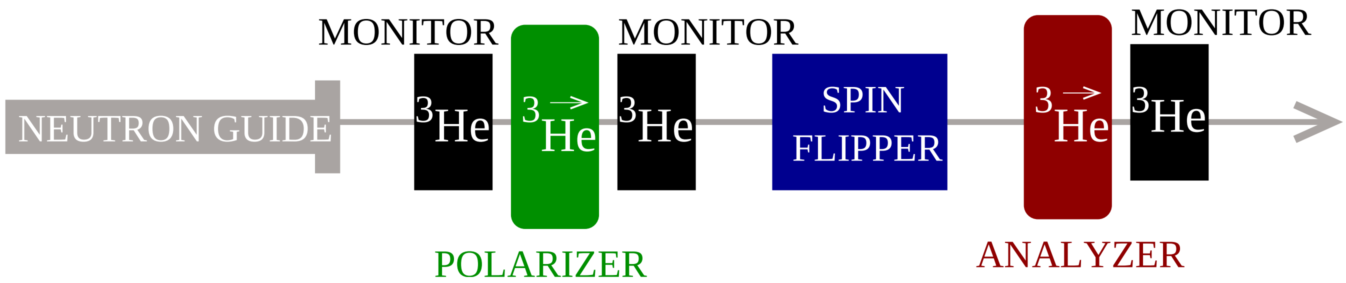
$$T_0 = e^{-n\sigma l}$$

$$ln(T_0) = -n\sigma l \propto tof$$

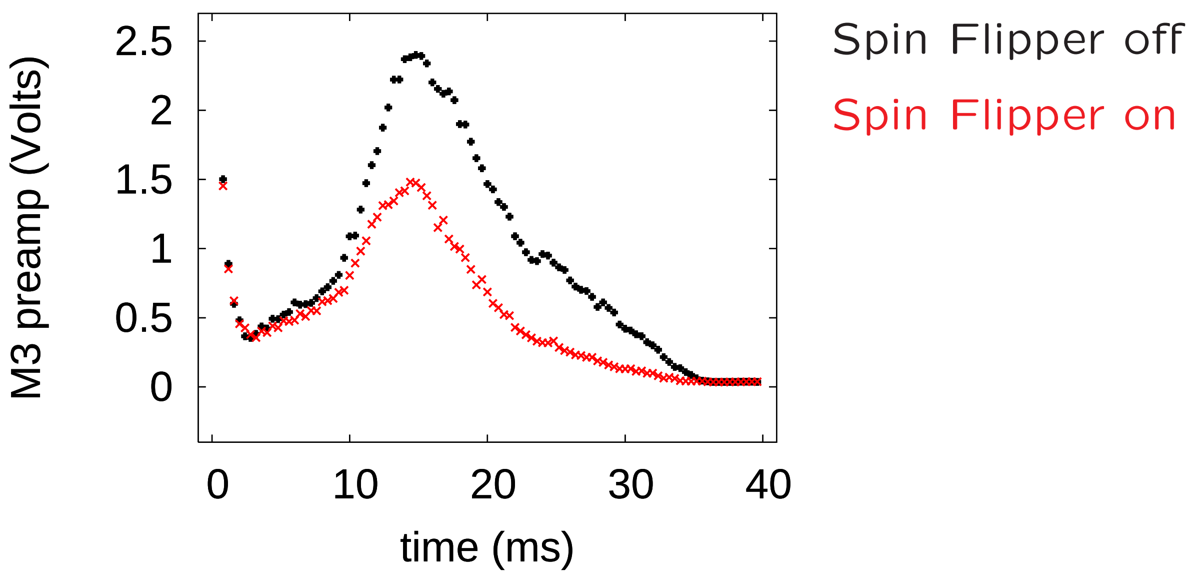


$$\mathrm{P}_3 = \frac{n_3 \sigma l P_3}{n_3 \sigma l} = \frac{0.0328\ ms^{-1}\ tof}{0.0714\ ms^{-1}\ tof} = 0.46$$

Spin Flipper Commissioning



Spin-dependent transmission of the analyzer cell can be seen in the third monitor:



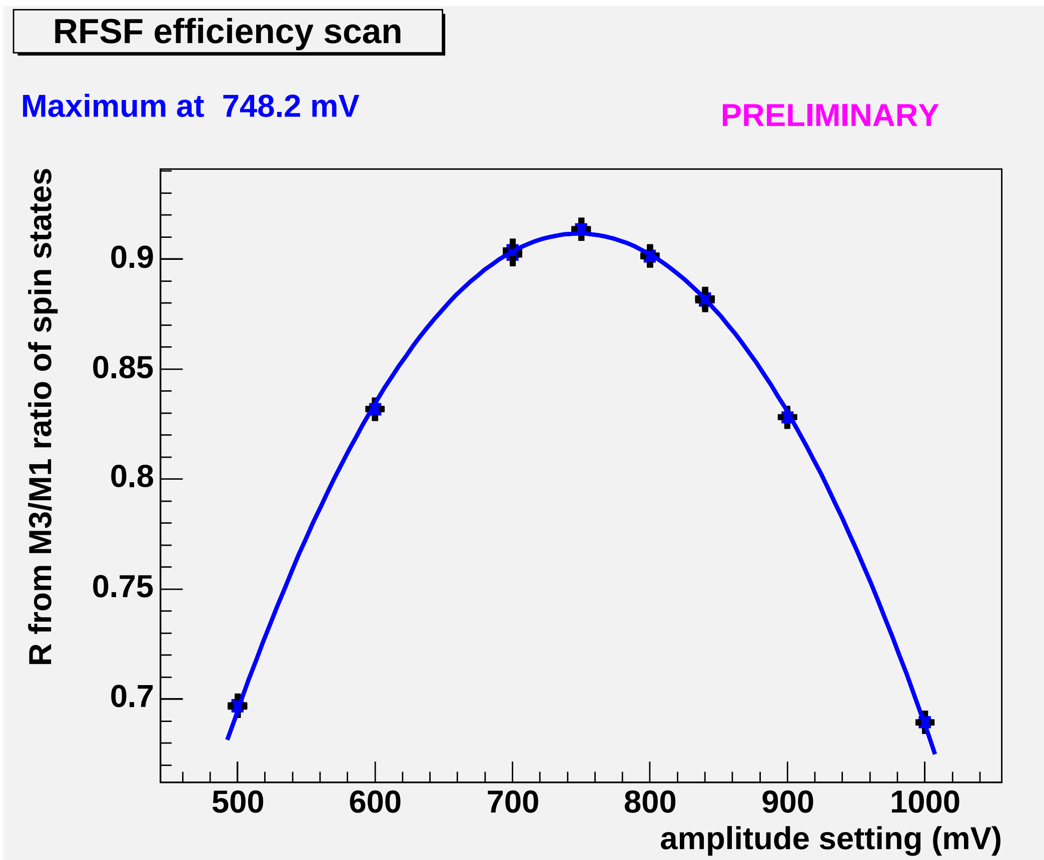
Spin flipper performs an imperfect flip:

$$P_n \rightarrow -RP_n \quad ; \quad R < 1$$

The ratio between spin flipper on and spin flipper off signals is dependent on polarizer and analyzer properties and R.

A Spin Flipper Scan

A scan through spin flipper settings determines the operating parameters corresponding to maximum efficiency



Important since:

- Spin flip efficiency enters into the asymmetry calculation.
- Maximizing spin flip efficiency minimizes running time.

Concluding Remarks

- Chad has written technical notes showing: that the effect of scattering (glass cell windows, Si oven windows, Al monitor windows) on polarization determination is 0.1%; and that the effect of cell curvature on polarization is 0.2%.

- The monitors and their preamps worked well in the commissioning run and should be fine for the production run.